File Ref. No.: CTW-006

VERIFICATION OF TRANSLATION

I hereby declare and state that I am knowledgeable of the Japanese and English languages and that I made and reviewed the attached translation of the attached patent application entitled "Battery Pack" from the Japanese language into the English language, and that I believe my attached translation to be accurate, true, and correct to the best of my knowledge and ability.

September 13, 2002
Date

Jun Yokoi
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Printed name

PATENT OFFICE
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Data of Application: September 27, 2000
Application Number: 2000-293719
Applicant: Makita Corporation

October 27, 2000
Commissioner, Patent Office Kozo Oikawa

Date of Application:

Reference No.: P2000-315

NAME OF DOCUMENT: Patent Application
REFERENCE NUMBER: P2000-315
ADDRESSED TO: Commissioner of Patent Office
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CLAIM OF PRIORITY BASED ON A PRIOR APPLICATION:
Application No.: Patent Application No. 11-321621
Date of Application: November 11, 1999
INDICATION OF FEE PAYMENT:
DEPOSIT LEDGER NO.: 009243
FEE: 21,000 yen
LIST OF DOCUMENTS FOR SUBMISSION:
NAME OF DOCUMENT: One specification
NAME OF DOCUMENT: One set of drawings
NAME OF DOCUMENT: One abstract
GENERAL POWER OF ATTORNEY NO.: 9003289
JPO VERIFICATION OF RECEIPT: Required

Date of Application:

Reference No.: P2000-315

NAME OF DOCUMENT: Specification

TITLE OF THE INVENTION: Battery Pack

CLAIMS:

1. A battery pack including air passages formed within a case containing a plurality of cells, the air passages allowing cooling air that enters the case from the outside of the case to pass along and/or between the cells and exit from the case,

the battery pack being characterized in that radiator plates are provided in the air passages so as to be in contact with outer surfaces of the cells, the heat capacities of the radiator plates increasing in the downstream direction.

2. A battery pack in accordance with claim 1, wherein the increase in the heat capacities is achieved by increasing the surface areas and/or the volumes of the radiator plates.

3. A battery pack in accordance with either claim 1 or 2, wherein the radiator plates are shaped so as to conform to the outer surfaces of the cells.

4. A battery pack including air passages formed within a case containing a plurality of cells, the air passages allowing cooling air that enters the case from the outside of the case to pass along and/or between the cells and exit from the case,

the battery pack being characterized in that radiator plates are provided in the air passages so as to be in contact with outer surfaces of the cells, the heat capacities of the radiator plates being varied in accordance with the heat condition of each cell.

5. A battery pack in accordance with claim 4, wherein the variation of the heat capacities of the radiator plates is achieved by varying the material of the radiator plates.

6. A battery pack in accordance with claim 4 or 5, wherein the variation of the heat capacities of the radiator plates is achieved by varying the areas of contact of the radiator plates with the cells.

7. A battery pack in accordance with any one of claims 4 to 6, wherein the variation of the heat capacities of the radiator plates is achieved by varying the thicknesses of the radiator plates.

DETAILED DESCRIPTION OF THE INVENTION

【0001】

Technical Field to Which the Invention Pertains

The present invention relates to a battery pack containing a plurality of cells for use in power tools and other devices, as a power source.

【0002】

Prior Art

A battery pack can be recharged by attachment of its common mounting portion with terminals onto a charger, and also can be used as a power source by attachment of the mounting portion onto an electric device, such as a power tool. However, the secondary cells tend to generate heat during each charge, which results in degradation of the battery. For this reason, a means for cooling the cells is provided in the battery pack. For example, disclosed in Japan Published Unexamined Patent Application No. 11-219733 is a structure for cooling secondary cells in a battery pack. The structure includes air passages running through the battery pack case and along and between the cells within the battery pack and intake and discharge ports provided at the top and bottom portions of the battery pack, whereby the intake ports are disposed at a mounting portion to which a charger is attached, with the air passages in communication with both the intake and discharge ports. Thus, cooling air from a fan incorporated in the charger can be introduced from the intake ports to be sent into the interior of the pack through the air passages and discharged to the outside of the pack from in order to provide cooling for the cells.

【0003】

The problem of the foregoing cooling structure is that the temperature of cooling air drawn into the battery pack case increases due to heat exchanged by the cells as the air flows downstream, thus resulting in a decreased cooling effect of the air downstream. In addition, as the cooling air comes into direct contact with the cells for cooling, the area of contact with the cooling air varies from cell to cell, such that the cells cannot be evenly or equally cooled. Such an uneven cooling effect often results in certain cells having higher temperatures than those of others, thereby allowing the cells with higher temperatures to reach the end of their service life faster than other cells. This by extension shortens the service life of the entire battery.

In view of the above, the object of the first invention in claim 1 is to provide a battery pack that can ensure a proper temperature balance among the cells by effectively dealing with increases in temperature of the cooling air in order to prolong the service life of the cells contained therein

【0004】

The cells may be unevenly or unequally cooled due to other causes than the foregoing, i.e., increases in temperature of the cooling air. For example, a cell or cells may experience a greater heat buildup if surrounded by other cells, thus creating an uneven temperature condition in the cells whether the surrounded cell or cells are located relatively downstream or upstream in the cooling airflow.

In view of the above, the object of the second invention in claim 4 is to provide a battery pack that can more effectively counter variations in temperature of the cells due to, for example, increases in temperature of the cooling air in the pack by ensuring a proper temperature balance among the cells in order to prolong the service life of the cells.

【0005】

Means to Solve the Problems

In order to achieve the above-identified problem, the first invention in claim 1 is characterized in that that radiator plates are provided in the air passages so as to be in contact with outer surfaces of the cells, the heat capacities of the radiator plates increasing in the downstream direction.

In addition to the object achieved by claim 1, according to the invention in claim 2, in order to easily increase the heat capacity of the radiator plate, the increase in the heat capacities is achieved by increasing the surface areas and/or the volumes of the radiator plates.

In addition to the object achieved by claim 1 or 2, according to the invention in claim 3, in order to efficiently and evenly provide cooling for the battery by utilizing the radiator plate, the radiator plates are shaped so as to conform to the outer surfaces of the cells.

【0006】

In order to achieve the above-identified problem, the second invention in claim 4 is characterized in that radiator plates are provided in air passages so as to be in contact with outer surfaces of the cells, the heat capacities of the radiator plates being varied in accordance with the heat condition of each cell.

In addition to the object achieved by claim 4, according to the invention in claim 5, in order to easily and efficiently vary the heat capacity of the radiator plate, the variation of the heat capacities is achieved by varying the material of the radiator plates.

In addition to the object achieved by claim 4 or 5, according to the invention in claim 6, in order to easily and efficiently vary the heat capacity of the radiator plate, the variation of the heat capacities is achieved by varying the areas of contact of the radiator plates with the cells.

In addition to the object achieved by any one of claims 4 to 6, according to the invention in claim 7, in order to easily and efficiently vary the heat capacity of the radiator plate, the variation of the heat capacities is achieved by varying the thicknesses of the radiator plates.

【0007】

Embodiments of the Invention

Preferred embodiments of the present invention will be described hereinafter with reference to the attached drawings.

Embodiment 1

First, an embodiment corresponding to the first invention will be described. Figure 1 is a perspective view of a battery pack and Figure 2 is an exploded perspective view of the battery pack. The battery pack 1 is formed of a double-structured box-shaped enclosure which contains a plurality of secondary cells (referred to as "cells" hereinafter), including an outer enclosure 2 housing an inner case 13 enclosing the cells, with the inner case formed one size smaller than the outer enclosure. The outer enclosure 2 includes a lower enclosure 3 generally housing the inner case 13 and an upper enclosure 4 screwed to the lower enclosure 3 from the above. Provided on the top surface of the upper enclosure 4 forming a mounting portion to which a charger (as will be described later) is to be attached are a top end 5 and a pair of parallel slide rails 6 extending in a forward direction from the top end 5 (the part of the battery pack 1 where the top end 5 is located is referred to as the rear). Each slide rail 6 includes an outwardly extending flange 7, thus forming an inverted L-shaped cross section. Provided at the top end 5 between and parallel to the pair of slide rails 6 are slits 8. Additionally, provided in the central rear portion of the top end 5 in the upper enclosure 4 is a rectangular intake port 9 which passes through the upper enclosure 4. Also provided in the upper enclosure 4 forward of the top end 5 are discharge ports 11 which form openings on the boundary of a step 10 formed between the slide rails 6.

【0008】

The inner case 13 includes a synthetic resin upper holder 15 and a lower holder 16 which are affixed to the upper and lower sides, respectively, of an assembly of twenty cells 14 held therein, the cells 14 being arranged in four rows of five cells each. The inner case 13 further includes belt-shaped metal radiator plates 22 provided between the upper holder 15 and lower holder 16. The upper holder 15 and lower holder 16 are shaped and dimensioned so as to stably encase the cells 14. Furthermore, ribs 17 and 18 having edges which conform to the inner surface of the lower enclosure 3 are provided along the lower rim of the upper holder 15 and the upper rim of the lower holder 16, respectively, so as to prevent jarring or rattling of the cells within the outer enclosure 2 when the inner case 13 is held therein. Furthermore, in this structure, the cells 14 are spaced apart and separated into two groups (each of the divided groups of cells 14 hereinafter is referred to as a "cell

group") held by the upper holder 15 and lower holder 16, with each group containing half the total number of cells.

【0009】

In addition, provided at the front and rear ends of the lower holder 16 are extended portions 19 which protrude from the ribs 18 and are joined to the upper holder 15 such that, as shown in Figures 3 and 5, the radiator plates 22 provided on the outer sides of each of the cell groups are secured by being fitted between the upper holder 15 and lower holder 16 along the lengthwise direction between the ribs 17 and 18 and the cells 14, and vertically in the shorter direction between the extended portions 19 and the cells 14. Similarly, the radiator plates 22 provided between the cell groups are fitted in the lengthwise direction between the respective cells 14 and partition plates 20 which protrude between the cell groups from the upper holder 15 and lower holder 16, and in the shorter direction between the extended portions 19 and the cells 14. Furthermore, each radiator plate 22 defines the projections and recesses so as to conform to the outer surfaces of the cell group, thus providing equal contact between the radiator plates 22 and the cells 14. Additionally, as shown in Figures 2 and 6, four fins 23 are formed in parallel on the outer surfaces of the radiator plates 22, beginning at the front end thereof and extending in the rearward direction. With the exception of the uppermost fin, the three lower fins 23 are disposed laterally in a step-like arrangement such that the lengths of the fins increase towards the lowest fin and thus the surface area and volume of the radiator plates 22 increases with proximity to the front of the battery pack.

【0010】

Thus, the cell groups are enclosed in a substantially sealed manner within the inner case 13, defining within the outer enclosure 2, as indicated by the hatched area in Figure 5, a space that surrounds the inner case 13 between the ribs 17 and 18 and another space that communicates with that space penetrating from the rear to the front of the inner case 13 in the lengthwise direction. The forward and rear portions of the rib 17 are recessed so as to place these spaces in communication between the intake port 9 and the discharge ports 11 of the upper case 4. Thus, as indicated by the arrows in Figure 6, within the battery pack 1, air entering from the air intake port 9 is separated into airflows which go through air passages defined by the spaces, with first air passages 24 leading from the intake port 9 to the exterior via the discharge ports 11 in two symmetrical and peripheral routes and a second air passage 25 which penetrates the inner case 13 and extends forward also to the exterior from the discharge ports 11. Furthermore, vertically-disposed air current

adjustment plates 21 are provided on the front extended section 19 on both sides of the second air passage 25, causing the flow of air through the first air passages 24 and the flow of air through the second air passage 25 to be guided to the exhaust ports 11 independently.

Additionally, reference numeral 26 designates a rubber sheet 26 laid between the bottom surface of the inner case 13 and the inner surface of the lower case 3, whereas reference numeral 27 designates sponge sheets laid between the cell groups and the lower holder 16, and reference numeral designates 28 insulating sheets. Furthermore, provided in the rear of the battery pack 1 on the outer enclosure 2 is a hook 30 upwardly biased by a coil spring 29 such that a prong 31 of the hook protrudes upward through the upper case 4 when the battery pack 1 is assembled.

【0011】

Additionally, a board 32 is secured with screws to the rear of the upper surface of the upper case 15 (shown in Figures 2-4 and 6). Laterally disposed on the upper side of the board 32 are charge/discharge terminals 33. Lead connector plates 34 electrically connect the charge/discharge terminals 33 with the positive and negative electrodes of the terminal cells of the cell groups exposed through the upper holder 15. Provided between the charge/discharge terminals 33 are a temperature detection terminal 35 and a connector-type data transmission terminal 36. When the board 32 is housed in the outer enclosure 2, the charge/discharge terminal 33 and the temperature detection terminal 35 are exposed to the exterior environment through the slits 8 formed in the upper enclosure 4 with the data transmission terminal 36 also exposed in the forward direction. Furthermore, each charge/discharge terminal 33 is formed longer than the temperature detection terminal 35 so as to achieve the necessary contact pressure when the battery pack is attached to a power tool.

Furthermore, as shown in Figure 2, a thermostat 37 connected to the temperature detection terminal 35 and leads 39 pass downward through one of through-holes 38 in the front end of the upper holder 15, and the thermostat 37, in attachment to the bottom holder 16, is inserted between the cells 14 and the extended portion 19 and affixed to the cells 14. Here, an inclined surface 40 is provided on the inner surface of the extended portion 19 so as to keep the thermostat 37 pressed against the cells 14 upon insertion of the thermostat 37.

【0012】

Figure 7 is an overall view of a charger 50 onto which the battery pack 1 is set. The charger 50 includes a box-shaped main case 51 comprised of an upper case 52 and a lower case 53, containing an internal board comprising a charging circuit,

with a connecting portion 54 formed in the upper side of the upper case 52 to which the battery pack 1 can be removably attached. The connecting portion 54 includes a pair of parallel guide rails 55 which are spaced apart by a distance greater than the distance between the outermost edges of the flanges 7 of the slide rails 6 on the battery pack 1. In addition, an extension 56 projects inward from the top surface of each guide rail 55. Upon inversion of the battery pack 1 so as to orient the top end 5 side downward, the slide rails 6 of the battery pack 1 are inserted between the guide rails 55 at the rear of the charger 50 (the closer end of the charger as seen in Figure 7 will be hereafter referred to as its rear) and slid on, so that the rails engage each other and the guide rails 55 can hold the slide rails 6 therebetween. The battery pack 1 comes to a stop when stoppers 12 provided at the farthest rear corners of the top end 5 of the battery pack 1 come into abutment with the rear ends of the guide rails 55.

In addition, formed in the connecting portion 54 of the charger 50 is a rear portion 58 and a front portion 57 which is generally located at a higher plane than the rear portion 58 so as to form a step therebetween that spans the guide rails 55. The front portion 57 provides a flat surface which abuts and supports the step 10 of the battery pack 1 when the battery pack 1 is set in place.

Furthermore, the connecting portion 54 is sloped generally downward to the front end thereof such that the weight of the battery pack 1 facilitates the battery pack's sliding motion and stabilizes the battery pack 1 when it is set at the end position.

【0013】

Also provided in the rear portion 58 is a terminal block 59 on which charging terminals 60, a temperature detection terminal 61, and a connector-type data transmission terminal 62 are arranged. Referring to Figures 8 and 9, a cooling fan 63 is provided inside the main case 51 rearward of the terminal block 59. The fan 63 is positioned along the longer side of the main case 51 and the fan's upwardly-directed airflow supply port 64 is connected in communication with a square airflow passageway 66 which is formed in the upper case 52. Reference numeral 67 designates air intake ports formed in the lower case 53 for drawing in cooling air. Furthermore, a partition wall 68 is provided in the lower case 53 so as to enclose the fan 63, whereas a vertically-disposed partition wall 69 is provided in the upper case 52 so as to conform to the upper surface of the fan 63 other than the portions connecting the airflow supply port 64 and the airflow passageway 66. In this way, only air from the exterior of the charger 50 is supplied to the fan 63 through the fan's intake port 65, which faces rearward such that the supplied air is sent

upwards.

【0014】

During charging of the battery pack 1 thus constructed, when the slide rails 6 of the battery pack 1 are placed between the guide rails 55 of the charger 50 and the battery pack is slid forward until the stoppers 12 come into abutment with the rear ends of the guide rails 55 as described above, the charging terminals 60 and the temperature detection terminal 61 in the terminal block 59 advance into the slits 8 of the top end 5 and make electrical contact with the corresponding charge/discharge terminals 33 and the temperature detection terminal 35, respectively, while the data transmission terminals 36 and 62 are also brought into electrical contact, and charging begins. As shown in Figure 10, in this state of attachment, the air intake port 9 of the battery pack 1 is positioned directly above the airflow passageway 66 of the charger 50, placing both channels in communication with each other.

【0015】

During a charge, the heat radiator plates 22 radiate the heat generated by the cells 14 that is transferred to the heat radiator plates 22. The fan 63 simultaneously starts operation at the start of charging, thus cooling air drawn through the air intake ports 67 is discharged upwards from the airflow supply port 64, and this airflow, as indicated by the dotted-line arrows, is introduced through the airflow passageway 66 of the charger 50, after which it proceeds through the air intake port 9 of the battery pack 1 and on to the interior of the outer case 2, passes along the first air passages 24 and the second air passage 25 from the rear of the battery pack 1 (Figure 10 shows the airflow along the second air passage 25), and is discharged to the exterior from the discharge ports 11. Thus, the radiator plates 22 are cooled by the airflow described above, thereby suppressing increases in temperature of the cells 14. In particular, the number of the fins 23 increases in the downstream direction. Accordingly, even if the temperature of the cooling air increases due to heat exchange by the radiator plates 22 as it flows downstream along the radiator plates 22, the radiator plates' heat capacities, which increases in the downstream direction with the number of fins, can counteract this problem, achieving the cooling effect of the radiator plates along their entire length. In addition, each radiator plate 22 defines the projections and recesses so as to conform to the outer surfaces of the cell group, thus providing equal contact between the radiator plates 22 and the corresponding cells therein. This in turn realizes even heat transfer from the cells 14 to the radiator plates 22.

【0016】

According to the above embodiment, the battery pack 1 has a dual structure in which the cells 14 are housed in the inner case 13, which is in turn contained within the outer enclosure 2 with the first air passages 24 and the second air passage 25 separated from the cells 14. Additionally, the radiator plates 22 are provided in the part of the first air passages 24 and the second air passage 25 where they come into contact with the outer surfaces of the cell groups, with each radiator plate having on its surface fins 23, the number of which increases toward the downstream direction of the cooling airflow. This results in a greater heat capacity of each radiator plate 22 in the downstream direction of the airflow and thus ensures an appropriate cooling effect of the plates 22 despite increases in temperature of cooling air downstream. Due to this arrangement, the cells 14 have an even temperature distribution, resulting in an increase in the overall service life of the battery. Moreover, the provision of the fins 23 augments the surface area and volume of the plate and thus the overall heat capacity of each radiator plate 22.

In addition to the above, the radiator plates 22 is shaped so as to conform to the outer surfaces of the cell groups, thus providing equal contact between the radiator plates 22 and the corresponding cells 14 therein and more effectively realizing even cooling of the cells.

【0017】

The shape of the radiator plate is not limited to that described in the foregoing embodiment. As shown in Figure 11, the radiator plate may be redesigned to provide an alternative radiator plate 41 with a greater height and an accordingly increased provision of fins 42, depending on the length of the cells used. Furthermore, instead of providing a separate radiator plate (22 or 41) for each row of cells as in the foregoing embodiment, a U-shaped radiator plate may be employed to surround two rows of cells. Alternatively, shorter radiator plates having different numbers of fins may be connected in the longitudinal direction. Other modifications may be made to the radiator plates to suit the arrangement or shape of the cells. Furthermore, the heat capacities of the radiator plates may be increased in a number of ways: each radiator plate may be formed gradually thicker in the downstream direction of the airflow; protrusions rather than fins may be formed on the surface of the plate with their number gradually increased downstream; the similar effects may be realized by changing either the surface area or the volume only. Although fins oriented in parallel to the cooling airflow is the most preferred configuration due to their airflow straightening or adjusting effect, rib-like structures that protrude farther from the surface of the radiator plate may also suffice.

The foregoing embodiment employs a fully double-structured casing in which the cells are held in the inner case in order to define air passages. Instead, only air passages may be separated from the space for housing the cells by partition walls, with the radiator plates disposed in the partition walls so as to be brought into contact with the cells.

【0018】

Embodiment 2

An embodiment corresponding to the second invention will be described hereinafter. This embodiment differs from the first embodiment only in the arrangement of the cells and the structure for providing cooling effects, such that other elements including the outer enclosure and the structure for coupling to the charger are identical to those of the first embodiment. Accordingly, identical or similar reference numerals denote identical elements and description of such elements is omitted, and the structure of the inner case is first described.

The battery pack 1 shown in Figure 12 holds ten fewer cells than in the first embodiment are contained, providing a 12-volt pack. The inner case 13 contains two cell groups 70, each group including a row of four cells 14a-14d, with another cell group 71 including a row of two cells 14e and 14f interposed between the cell groups 70. As shown in Figures 13 and 14, due to the fewer number of cells than provided in the first embodiment, no air passage is provided along the outer surfaces of each cell group 70; rather, an air passage 72 is defined by the opposing inner surfaces of the cell groups 70 and the horizontal partition plates 20 along the middle portions of the upper and lower holders 15 and 16 and is bifurcated along both sides of the central cell group 71. Additionally, reference numerals 73 and 74 designate radiator plates provided on the opposing surfaces of the cell groups 70 and a radiator plate 74 that completely surrounds the cell group 71, respectively. The radiator plates 73 are made of a metal corrugated in such a manner as to conform to the outer surfaces of the corresponding cells 14a-14d. As with the radiator plates of the first embodiment, the radiator plates 73 are assembled between the upper and lower holders 15 and 16 in contact with the cells 14a-14d. The radiator plate74 is made of a synthetic resin that surrounds and conforms to the shapes of the outer surfaces of the cells 14e and 14f and is formed integrally in the lower holder 16.

【0019】

Each radiator plate 73 has portions with differing surface areas in circumferential contact with the cells 14a-14d. With reference to Figure 15, the radiator plate has the greatest area of contact (S4) with the fourth cell 14d, positioned farthest downstream, the second greatest area of contact (S2) with the

second cell 14b, the third greatest area of contact (S3) with the third cell 14c, and the least area of contact (S1) with the first cell 14a. In this manner, the area of contact is gradually decreased. The reason for the contact areas generally increasing downstream is that as the temperature of the cooling air through the air passage 72 increases as it flows downstream by heat exchange with upstream cells, the effect would otherwise be lower on downstream cells, such as the cell 14d, if the contact area were the same for each cell. On the other hand, the areas of the second and third cells 14b and 14c are made greater than that of the first cell 14a because these cells, being interposed between other cells, are less effectively cooled for the same area of contact.

Being interposed between two adjacent cells further downstream from the second cell 14b, the third cell 14c should require a greater area of contact with the radiator plate than the second cell 14b does. However, a sufficient area of contact cannot be secured for this cell as the cells are not arranged straight but curved toward the opposing cell group. Instead, the radiator plate 73 includes two bulges 73a on both edges of the plate's contact area with the third cell 14c. These bulges are thicker than the other parts of the radiator plate. This is to increase the heat capacity of the radiator plate 73 for the cell 14c and enhances the cooling effect on the cell 14c.

【0020】

The radiator plate 74 for the cell group 71 is made of synthetic resin as the lower holder 16 in which the plate 74 integrally formed. The reason for this is that this group contains only two cells and its radiator plate 74 is exposed to cooling air around its entire peripheral wall so that the same degree of a cooling effect is expected on this cell group 71 as that on the other cell groups 70 even though this radiator is not made of metal. However, considering increases in temperature of the cooling air as it proceeds downstream, the portion 74a of the radiator plate 74 that surrounds the downstream cell 14f is made thinner than the portion of the plate that surrounds the upstream cell 14e so as to realize an equal cooling effect on both cells.

The lower holder 16 of the inner case 13 includes a guide passage 76 which extends upwardly therein and which, upon assembly, is connected to and aligned with a cylindrical channel 75 extending downward from the intake port 9 so as to place the entrance to the air passage 72 in hermetic communication with the intake port 9. The guide passage 76 includes at its bottom two valleys 77 to facilitate separation of cooling air into the left and right branches of the air passage 72. Reference numerals 78 and 79 designate airflow straightening ribs provided

vertically on the front surfaces of the upper and lower holders 15 and 16, respectively. The ribs 78 and 79 abut the inner surfaces of the outer enclosure 2 upon placement of the holders in the outer enclosure 2 so as to direct the cooling air from the outlet of the air passage 72 into the discharge ports 11.

【0021】

To charge the battery pack 1 so constructed, the pack detachably engages the charger 50 by means of the guide rails 55 of the charger 50, as in the first embodiment. Upon attachment of the device to the charger 50, the intake port 9 of the battery pack 1 is positioned directly above the airflow passageway 66 of the charger 50, thus establishing communication of the air passages between the two devices.

Upon commencement of charging, the fan 63 sends cooling air into the outer enclosure 2 via the airflow passageway 66 of the charger 50, the intake port 9 of the battery pack 1, and its cylindrical channel 75. The cooling air continues to flow through the guide passage 76 of the lower holder 76 and the air passage 72 within the inner enclosure 13 and eventually exits to the exterior through the discharge ports 11, thereby suppressing increases in temperature of the cells by cooling the radiator plates 73 and 74. Particularly in this embodiment, different materials are selected for the radiator plates 73 and 74 in consideration of the difference in the heat conditions between the positions of the cells. Furthermore, the cells in the cell group 70 have different areas of contact with the radiator plate 73, and the thickness of each of the radiator plates 73 and 74 varies so as to provide different heat capacities for different cells. Accordingly, these arrangements can effectively cope with variations in the temperature of the cells 14a-14f, for example, due to increases in temperature of the cooling air downstream, maintaining a proper temperature balance among the cells 14a-14f. This addresses the problem of certain cells reaching the end of their life span faster than others, thus increasing the service life of the entire battery more effectively than the arrangement of the first embodiment. Moreover, the charging time is shortened.

Moreover, as the heat capacities of the radiator plates 73 and 74 is adjusted by the selection of different materials for the plates 73 and 74, the use of differing areas of contact of the cells in each group 70 with the plate 73, and the provision of differing thicknesses in the radiator plates 73 and 74, the heat capacities of the radiator plates 73 and 74 can be more easily and effectively adjusted. If more than one of these means are combined, adjustment of the heat capacities of the plates becomes even easier and more accurate.

【0022】

In the foregoing second embodiment, all three features, i.e., the selection of different materials for the plates 73 and 74; the use of differing areas of contact of certain cells with the radiator plates; and the adjustment of the plate thickness, are employed. However, one or two of the features may be adopted if a proper temperature balance can be attained among the cells.

The foregoing embodiment has the structure including only a central air passage. However, if air passages are provided along the outside surfaces of cell groups, as in the first embodiment, any combination of the features, i.e., the selection of different materials for the radiator plates; the use of differing areas of contact of certain cells with the radiator plates; and the adjustment of the plate thickness, can be still employed as desired.

The material for the metal radiator plate can be selected from aluminum, copper, iron, and any other metals in order to achieve even temperature distribution among the cells. Furthermore, a number of different materials corresponding to different cells can be used in a single radiator plate. The thickness distribution and/or areas of contact in any of the radiation plates can also be changed depending on the number and arrangement of the cells and the configuration of the air passages. For example, a cell's area of contact with a radiator plate can be adjusted by increasing or decreasing the contact area along the axis of the cell rather than along the circumference of the cell.

【0023】

Effect of the Invention

According to the first invention in claim 1, by the provision of radiator plates in the air passages so as to be in contact with the outer surfaces of the cells in such a manner as to increase the heat capacity of each plate in the downstream direction of cooling airflow, increases in temperature of the cooling air can be effectively countered, and a proper temperature balance can be maintained among the cells by maintaining the cooling effect of the radiator plates, thereby prolonging the service life of the entire battery.

In addition to the effect of claim 1, according to the invention in claim 2, by increasing the surface areas and/or volumes of the radiator plates, the heat capacities of the radiator plates can also be easily increased.

In addition to the effect of claim 1 or 2, according to the invention in claim 3, by shaping the radiator plates to conform to the outer surfaces of the cells, the cells can be more evenly and efficiently cooled.

【0024】

According to the second invention in claim 4, by the provision of radiator plates in the air passages so as to be in contact with the outer surfaces of the cells in such a manner as to provide different heat capacities in accordance with the heat conditions of the corresponding cells, variations in temperature of the cells that occur due to, for example, increases in temperature of the cooling air can be more effectively countered, thus maintaining a proper temperature balance among the cells. Accordingly, this prevents certain cells from reaching the end of their life span faster than others, thus increasing the service life of the entire battery even more effectively than the first invention. Moreover, the charging time is shortened.

In addition to the effect of claim 4, according to the invention in any one of claims 5 to 7, the heat capacities of the radiator plates can be easily and effectively varied. If the inventions of claims 5 to 7 are combined, the heat capacities the radiator plates can be more easily and accurately varied.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of a battery pack of the first embodiment.

Figure 2 is an exploded perspective view of the battery pack of the first embodiment.

Figure 3 is a cross-sectional view of the battery pack of the first embodiment.

Figure 4 is a top plan view of the battery pack with the upper enclosure removed.

Figure 5 is a top plan view of the battery pack with the upper enclosure and upper holder removed.

Figure 6 is a perspective view of the inner case.

Figure 7 is a perspective view of a battery charger.

Figure 8 is a plan view of the portion the charger accommodating a fan.

Figure 9 is a cross-sectional view of the portion accommodating the fan.

Figure 10 is a cross-sectional explanatory view showing the battery pack mounted onto the charger.

Figure 11 is an explanatory view showing a modification of the radiator plates.

Figure 12 is an exploded perspective view of a battery pack of the second embodiment.

Figure 13 is a top plan view of the battery pack with the upper enclosure and the upper holder removed.

Figure 14 is a cross sectional view of the battery pack of the second embodiment taken along a longitudinal center line therethrough.

Figure 15 is an enlarged top plan view showing the structure of the radiator plates.

EXPLANATORY LEGENDS

1 – battery pack; 2 – outer enclosure; 5 – top end; 6 – slide rail; 9 – intake port; 11 – discharge port; 13 – inner case; 14 – cell; 15 – upper holder; 16 – lower holder; 22, 41, 73, 74 – radiator plates; 23, 42 – fins; 24, 72 – air passages; 25 – second air passage; 32 – board; 33 – charge/discharge terminal; 50 – charger; 51 – main case; 54 – connecting portion; 55 – guide rail; 59 – terminal block; 63 – fan; 66 – airflow passageway.

Date of Application:

Reference No.: P2000-315

NAME OF DOCUMENT: Abstract

ABASTRACT

OBJECTIVE: To maintain a proper temperature balance among secondary cells in order to prolong the service life of all the cells.

MEANS TO ACHIEVE THE OBJECTIVE: A battery pack 1 includes air passages through which cooling air which enters the pack at an intake port 9 flows within an inner case 13 before being discharged at discharge ports 11. Provided in the air passages within the inner case 13 are metallic radiator plates 73 which are in contact with cells 14a-14d and a radiator plate 74 made of synthetic resin which are in contact with cells 14e and 14f.

DESIGNATED DRAWING: Figure 12

NAME OF DOCUMENT: Drawings

FIGURE 1
FIGURE 2
FIGURE 3
FIGURE 4
FIGURE 5
FIGURE 6
FIGURE 7
FIGURE 8
FIGURE 9
FIGURE 10
FIGURE 11
FIGURE 12
FIGURE 13
FIGURE 14
FIGURE 15